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An Optimized, Economical and Painless Artificial Intelligence Technique to Diagnose Melanoma

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***Abstract* - Skin cancer is a deadly condition occurring in the skin. It is a gradually evolving condition which starts in the melanocyctes in skin. So it is also called as Melanoma. First it occurs in a small region and later spreads to other parts of the body through the lymphatic system. If the skin cancer is detected at the early stages, it can be cured. So an early detection system is inevitable in skin cancer diagnosis. Melanoma can be of Benign or Malignant. Malignant melanoma is the dangerous condition, while benign is not. At initial stages, both of them resembles in appearance. So a classification of benign and malignant melanoma is difficult. Only an expert Dermatologist can make correct classification. Conventional diagnosing procedures include preliminary diagnosis by direct observation by doctors and Biopsy method for confirmation. Biopsy method is a painful and time consuming one. So an efficient classification system using Artificial Intelligence (AI) and Image Processing Techniques (IPT)is proposed. Dermoscopic images are given as input to the system. Images contain noises and hairs. The noises are removed using image processing techniques. After that, region of interest or suspicious region of skin is separated from normal skin using Segmentation. Segmentation method used here is Color Threshold Segmentation. Two feature extraction techniques used- Gray Level Co-occurrence Matrix (GLCM) method and Red, Green, Blue (RGB) color features. These features are gives as the input to Artificial Neural Network Classifier. It classifies the given data set into Cancerous and Non-cancerous.**

***Keywords* – Melanoma, Segmentation, RGB features, Gray Level Co-occurrence Matrix, Artificial Neural Network.**

I. INTRODUCTION

Skin is the largest organ in human body. Skin cancers are the most common form of cancers in humans. It is a deadly type of cancer affecting the skin. Normally new skin cells are reproduced in a controlled way so as to replace old ones. Skin cancer is a condition in which, there is appearance of cancerous cells. Cancerous cells are the skin cells that have abnormal growth. It continues to reproduce and spread to other body parts. Skin cancer is also known as Melanoma, since it occurs in the melanocytes present in skin. Melanocytes are the color giving pigments in the skin. Melanoma cells usually continue to produce melanin leading to the cancers with mixed shapes and colors. Melanoma has different texture, geometry, and color when compared with normal skin. Melanoma is classified into two- Benign Melanoma and Malignant Melanoma. Benign Melanoma is not a dangerous condition. It is simply appearance of moles. The growth of those melanomas cease after a particular size. Malignant Melanoma is the most dangerous form of all skin cancers. Malignant melanoma [1] is a highly malignant skin cancer, which grows rapidly and sometimes with different colors and abnormal shapes. It is gradually evolving and spreading. If Malignant melanoma is identified at its early stages, patients can be saved. Early diagnosis is more than 90% curable and late diagnosis is less than 50%. But the problem for identifying is that, both Benign and Malignant Melanoma show some similarities during its initial stages. Only an expert Dermatologist can correctly classify which one is malignant and benign.

Conventional method for skin cancer diagnosis is Preliminary observation and Biopsy method. Primary observation or preliminary observation is performed by doctor. In this method, the doctor makes a screening test by considering some unique features of Malignant melanoma like Asymmetry, Border Irregularity, Color Variation, Diameter. These features are commonly called as ABCD parameters. Malignant melanoma is distinguished from Benign Melanoma by these features. Malignant Melanoma is characterized by Asymmetry, whereas benign melanoma is symmetrical. Malignant melanoma has irregular Borders unlike Benign. Malignant Melanoma has the unique feature of variegated Coloring whereas benign has uniform coloring. Size of benign melanoma is less than 6mm, that of malignant case is greater than 6mm. These are the features considered by doctors for the primary diagnosis. But only an expert dermatologist can make correct classification based on such features. For the purpose of conformation, Biopsy method is used. It is the widely used medical diagnosing procedure. Biopsy method involves the removal or scrapping off the skin sample and this sample undergoes laboratory testing. It is a painful method and time consuming one. So, there has always been lack of less dangerous and time-consuming methods.

Considering the above scenario in skin cancer diagnosis, an effective, economicaland less time consuming Artificial Intelligence based classification is proposed. The methodology uses Artificial Intelligence and Image processing for the skin cancer diagnosis [2]. This classification is very efficient and saves a lot of time of

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patients as well as doctors. The patient himself can do the diagnosis. The cost of the diagnosis is low compared to the conventional diagnosis techniques.

II. ARTIFICIAL NEURAL NETWORK BASED MELANOMA CLASSIFICATION

Artificial Neural Network (ANN) based skin cancer diagnosis is a diagnosing technique in which ANN is used as a classifier for classifying benign and malignant melanomas. This methodology uses Digital Image Processing technique and Artificial Intelligence for the classification. The different steps involved in the classification technique are shown in Fig. 1. The first stage is the collection of Dermoscopic images. The dermoscopic images are in digital format. The Dermoscopic images were taken using a Dermatoscope [6]. The dermoscopic images contain noises as well as hairs. These noises may cause error in classification. They need to be removed before further processes. For that purpose Image processing techniques are used. 'Dull Razor' is used to remove hairs from the images. This software is used for Medical image processing purposes. Other noises are removed by filtering. From the filtered image, Region Of Interest (ROI) is separated from the background by the method of Segmentation. Color Threshold segmentation is done here. Segmentation is performed in IMAGE J software. There are some unique features that distinguish Malignant Melanoma from Benign Melanoma. Such features are selected using feature extraction techniques. Two feature extraction techniques are used – Normalized RGB Chromaticity and Gray Level Co-occurrence Matrix method. These two methods extracts geometrical as well as color features of the image. Total seven features were extracted. These features are given as inputs to the ANN classifier. Since there are 7 features, there will be 7 input neurons, 4 hidden neurons and one output neuron. The output of the classifier is 0 or 1. Zero represents Non-cancerous condition and, one represents cancerous condition.

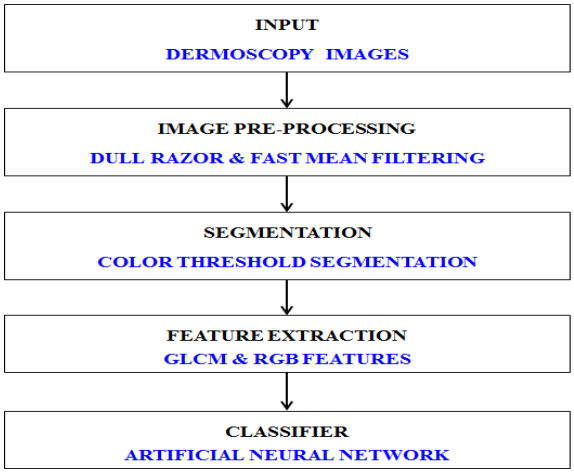
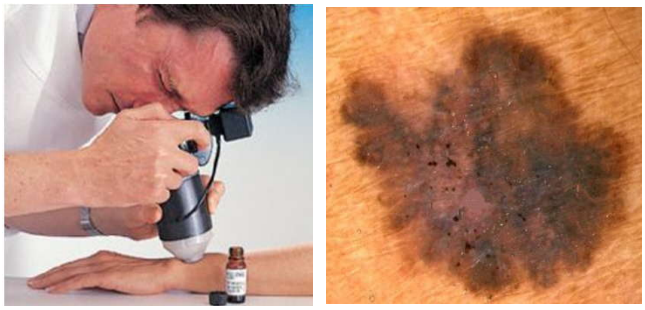


Fig. 1. Flowchart for classification

A. Dermoscopy

Dermoscopy is an imaging technique by which skin images are captured using a Dermatoscope[11]. Dermoscopy is also known as Dermatoscopy or Epiluminescence Light Microscopy (ELM).

The dermoscopic images are captured by placing an oil immersion between the skin and the optics. Lens of a microscope is placed directly, illuminating sub-surface structures. Lighting is provided from both sides of the lens at an angle of 45^0. The lighting magnifies the skin region and reveal most of the pigmented structure, different color shades that is not visible to naked eye. ELM devices are currently being used by physicians to improve visual inspection of skin lesions. ELM with Digital Capture system is used in this methodology. The image obtained from such a dermatoscope is called Dermoscopic Image. It is shown in Fig. 2(b).



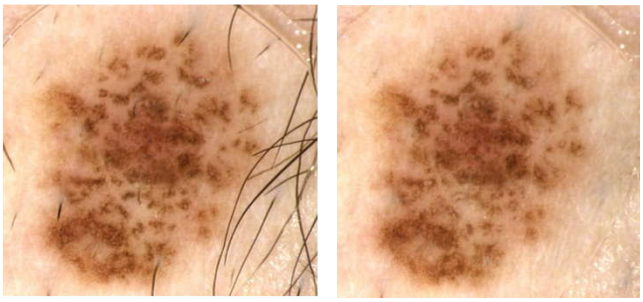
(a) Dermatoscopy (b) Dermatoscopic image

Fig. 2. Dermoscopic method

Dermoscopy can be done by either the non-contact or the contact technique. In the contact technique, the glass plate of the instrument comes in contact with the skin surface. In contrast, in the non-contact technique, there is no contact of the lens with the skin. Fig. 2(a) shows Contact type Dermoscopy.

B. Image Processing

The Dermoscopic Image in Digital format is subjected to various Digital Image Processing Techniques. All the images should have uniformity in image size. The standard image size is taken as 360x360 pixels. All the images are resized using 'Picture Resize' Software. Dermoscopic images contain hairs, noises, bubbles etc. These may lead to errors in classification. These noises are removed using various Image Processing techniques. Two steps are involved- Pre-processing and Post processing.



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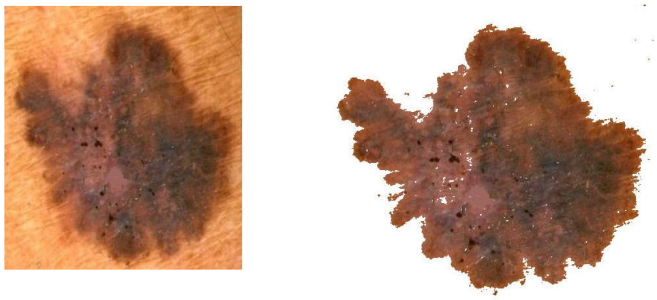
(a) Image containing hairs (b) Image after hair removal

Fig. 3 Hair removal using Dull Razor

In Pre-processing stage, the hairs are removed. Hairs are removed using 'Dull Razor', Medical Imaging Software. The hair removal using Dull Razor software is shown in Fig. 3. Post processing involves the filtering and image enhancement. The filtering method used here is Fast Mean Filtering (FMF). Fast Mean filtering is an image filtering method in which each pixel value in an image is replaced with the mean or average value of its neighboring pixels including itself. Fast Mean filtering algorithm has the advantage that, it has faster computational algorithm than Mean filtering[3]. This filter eliminates the pixel values which are non-representativeof their surroundings. Thus noises are eliminated. In addition, contrast enhancement can sharpen the image border and improve the accuracy for segmentation.

C. Segmentation



(a) Original Image (b) Color Segmented Image

Fig. 4 Segmentation

Next stage is the segmentation of the processed image. Segmentation is the method of separating the Region Of Interest (ROI) from an image. Here the ROI is the suspicious region in the skin. Segmentation separates the suspicious region from the healthy skin[5]. The presence of skin along with the ROI may cause error in classification. Color Threshold Segmentation is used here. This method thresholds images based on Hue, Saturation and Brightness (HSB), Red, Green and Blue (RGB) components. Ranges of the thresholding filters can be set manually or automatically based on the pixel value components of an ROI. Another approach is to designate a separate threshold for each of the RGB components of the image and then combine them with an ANDoperation. Color Segmentation is done in IMAGEJ software. It provides a variety of segmentation techniques. The original and segmented images are showed in Fig. 4.

D. Feature Extraction

There are some unique features that distinguish malignant melanoma from benign melanoma. These features are selected for classification purpose. Feature extraction extracts the eminent and important features of image data, from the segmented image. The end result of the extraction task is a set of features, commonly called a feature vector, which constitutes a representation of the image. It makes the raw data more useful in processing. By extracting features, the image data is narrowed down to a set of features. Two feature extraction techniques are proposed here - Normalized RGB Chromaticity and Gray Level Co-occurrence Matrix (GLCM).

1) Normalized RGB Chromaticity: This is a color feature extraction method. One of the most predictive features in identification of malignant melanoma is variegated coloring.Variegation in color implies a high variance in Red (R), Green (G) and Blue (B) color components.By extracting the Red, Green, Blue Chromatic values, the variation of color pattern is obtained. Normalized value is obtained by dividing each color values by the sum of R, G, B color values.

$$\square\square = \frac{\square}{\square + \square + \square} \quad (1)$$

$$\square\square = \frac{\square}{\square + \square + \square} \quad (2)$$

$$\square\square = \frac{\square}{\square + \square + \square} \quad (3)$$

Here *Rn, Gn, Bn* are the normalized Red, Green, Blue color features.

2) Gray Level Co-occurrence Matrix (GLCM): GLCM is a matrix where the number of rows and columns is equal to the number of gray levels[7]. The GLCM is a tabulation of how often different combinations of pixel brightness values (gray levels) occur in an image.The Color Segmented image in gray scale is given as input. The GLCM is a powerful tool for image feature extraction by mapping the gray level co-occurrence probabilities based on spatial relations of pixels in different angular directions. The features extracted based on GLCM are: Contrast, Correlation, Energy, and Homogeneity. Contrast is the measure of contrast or local intensity variation. Correlation is a measure of gray level linear dependence between the pixels at the specified positions relative to each other.Homogeneity or Angular Second Moment is a measure of uniformity of an image. A homogeneous scene will contain only a few gray levels.

E. Artificial Neural Network Classifier

Classifier classifies the data set into Malignant and Benign Melanoma. In this methodology, a feed forward multilayer Artificial Neural Network is used as the Classifier[2]. Artificial Neural Network is a network of artificial neurons. It has wide applications like pattern classification and recognition, logical reasoning etc.The

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advantages of neural networks as classifiersare: Neural networks are data driven self-adaptive methods in which they can adjust themselves to the data. Neural Networks are able to solve highly complex problems due to the nonlinear processing capabilities of its neurons.

The neural network classifier structure consists of Input layer, Hidden layer and Output layer. The network is trained by giving the known data of both benign and malignant melanoma images. Learning algorithm [9] used is Back Propagation (BPN).Initially weights are initialized randomly. Input is given to the network and output is obtained. The output thus obtained is compared with desired output. If both are not same, then an error signal is generated. This error is propagated backwards and weights of the layers are adjusted so as to reduce the error.

In this proposed methodology, Seven Features are selected for classification. These features are given as input to a multilayer feed forward network. There is one input layer with seven input neurons, one hidden layer with four hidden neurons, and Output layer with one output neuron. Activation function used is Log Sigmoid function, which gives an output of 0 or 1. Zero represents non-cancerous or benign condition and one represents cancerous or malignant condition.

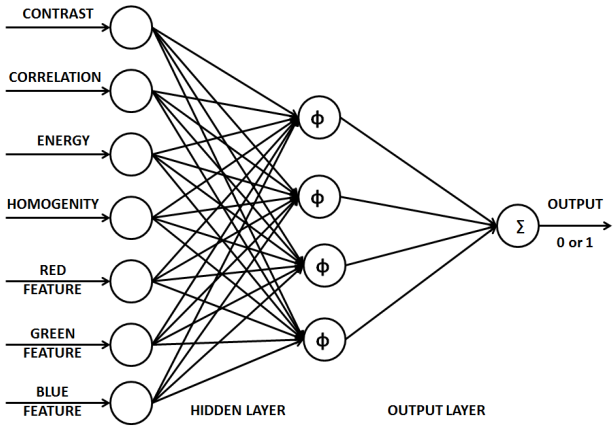

Fig. 5. Artificial Neural Network structure

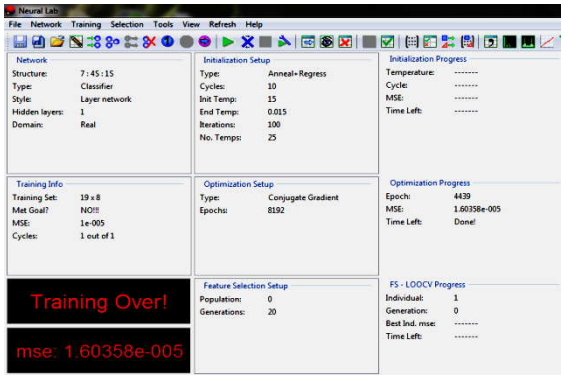

Fig. 6NEURAL LAB software

The classification is done inNeural Network Simulation software – NERURAL LAB. It is shown in Fig.5. First stage is the Network layer setup. Then Network is trained using known data set of both benign and malignant melanoma cases. Many epochs of training are repeated until Mean Square Error is less than a desired value. Once training is completed, datasets for classification are given to the network. Fifty Malignant and Benign Melanoma Features are given for classification. The output of the classifier is either 0 or 1. One represents cancerous (Malignant) conditionand Zero represents Non-cancerous (Benign) condition. Here the classification is done after optimizing Mean Square Error in NEURAL LAB

III. RESULTS

In this proposed system, Dermoscopic images were collected from prestigious cancer centers and Internet. The images were processed using various image processing tools. The images were converted to uniform size of 360x360 pixels using Image Resize software. The hairs in the images were removed by Dull Razor software. Additional noises were filtered using Fast Mean Filtering. After that, Filtered images were segmented by Color Threshold Segmentation (CTS). Features were extracted using GLCM and RGB Feature Extraction methods. Feature extraction was done in IMAGEJ and MATLAB software. The obtained Features were given as inputs to a Multi-Layer Feed Forward Neural Network (MLFFNN), with 7 input neurons, 4 hidden neurons and 1 output neuron. Activation function used is Log Sigmoid, which gives an output of 0 or 1. Zero represents non-cancerous or benign condition and one represents cancerous or malignant condition. The neural network is designed using NEURAL LAB software.

For classification, 50 cases were considered. The ANN classifier classified the given data into cancerous and noncancerous. Among that, 28 were classified as cancerous and 22 non-cancerous. The confusion matrix of classification is shown in Fig. 7. There were 7 misclassifications. The accuracy of this proposed system is 86 %.

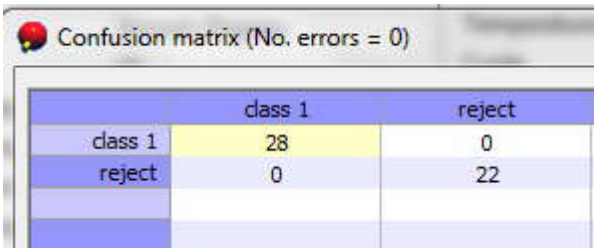

Fig. 7.Confusion Matrix of classified output

IV. RESULT VALIDATION

The obtained results were validated with Diagnosis results prepared by doctors, using the conventional diagnosing procedures. The dataset contained 26 Cancerous and 24 non-cancerous images, according to the doctors'

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diagnosis results. This dataset was the reference for validation. This proposed ANN based classifier gives the output of 28 cancerous and 22 non-cancerous conditions. There were 7 misclassifications. The obtained results show that the methodology has an accuracy of 86%. As the number of samples taken for classification is increased, the error will get reduced. By improving the image processing techniques and algorithms for training network, the accuracy of classification can be increased.

V. CONCLUSIONS

An economical, optimized and painless Artificial Intelligence based skin cancer diagnosing system is developed and proposed. It proves to be a better diagnosis method than the conventional Biopsy method. By using this methodology, patient can diagnose skin cancer without going to hospitals. It saves considerable amount of time of patients as well as doctors.Also the cost involved in this method is low. The diagnosing technique used Digital Image Processing Techniques and Artificial Neural Networks for the classification of Malignant Melanoma from benign melanoma. The dermoscopic images were used for classification. The images were subjected to various image processing techniques. ANN is used for classification purposes. The proposed system has an accuracy of 86%. The classification accuracy can be improved by incorporating better optimization techniques like Particle Swarm Optimization to train theArtificial Neural Network.

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TABLE I. RESULTS OF CLASSIFICATION

Contrast	Correlation	Energy	Homogeneity	Red Feature	Green Feature	Blue Feature	Output	Diagnosis
0.1966	0.9416	0.7685	0.9824	0.3405	0.3282	0.3313	0	Non-Cancerous
0.5299	0.9034	0.4532	0.935	0.3473	0.3244	0.3283	0	Non-Cancerous
0.0686	0.9817	0.8457	0.9906	0.3371	0.3315	0.3314	0	Non-Cancerous
0.0805	0.9842	0.7065	0.9788	0.3526	0.3278	0.3196	0	Non-Cancerous
0.3593	0.8986	0.6646	0.9492	0.3462	0.3297	0.3241	0	Non-Cancerous
0.1816	0.9557	0.8643	0.9903	0.337	0.3326	0.3303	0	Non-Cancerous
0.1065	0.9788	0.838	0.9932	0.3365	0.3325	0.331	0	Non-Cancerous
0.1726	0.9868	0.491	0.9814	0.3445	0.3282	0.3273	1	Cancerous
0.1777	0.7849	0.309	0.9153	0.3663	0.3419	0.2919	0	Non-Cancerous
0.1374	0.9861	0.3898	0.9738	0.3544	0.3224	0.3232	1	Cancerous
0.0905	0.9759	0.7606	0.9846	0.3428	0.3292	0.328	0	Non-Cancerous
0.1505	0.9879	0.635	0.9868	0.3365	0.3328	0.3308	1	Cancerous
0.171	0.9716	0.6388	0.9701	0.3445	0.3298	0.3257	1	Cancerous
0.3699	0.9135	0.337	0.9228	0.3659	0.3264	0.3077	0	Non-Cancerous
0.1843	0.9799	0.4884	0.968	0.3584	0.3296	0.312	1	Cancerous
0.1467	0.9772	0.6831	0.9858	0.3449	0.3327	0.3224	1	Cancerous
0.1065	0.9885	0.5597	0.988	0.3481	0.3327	0.3191	1	Cancerous
0.1356	0.9796	0.7934	0.9879	0.3368	0.3335	0.3297	0	Non-Cancerous
0.2871	0.9835	0.4315	0.9701	0.3541	0.3256	0.3203	1	Cancerous
0.6204	0.9553	0.3798	0.9589	0.344	0.3299	0.3261	1	Cancerous
0.1124	0.9602	0.73	0.977	0.3425	0.3317	0.3258	0	Non-Cancerous
0.1815	0.9718	0.4758	0.9684	0.3655	0.3308	0.3037	1	Cancerous

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0.2255	0.9702	0.5255	0.9689	0.3639	0.3289	0.3072	1	Cancerous
0.2252	0.9879	0.4977	0.9787	0.3375	0.3328	0.3297	1	Cancerous
0.3724	0.9611	0.5051	0.9639	0.3538	0.3324	0.3138	1	Cancerous
0.1117	0.9642	0.686	0.9815	0.3408	0.3328	0.3264	0	Non-Cancerous

REFERENCES

[1] Ho Tak Lau and Adel Al-Jumaily, "*Automatically Early Detection of Skin Cancer: Study Based on Neural Network Classification"*, International Conference of Soft Computing and Pattern Recognition, IEEE , pp 375-380, 2009

[2] Fikret Ercal, Anurag Chawla, William V. Stoecker, Hsi-Chieh Lee, and Randy H.Moss, "*Neural Network Diagnosis of Malignant Melanoma From Color Images"*, IEEE Transactions on Biomedical Engineering. vol. 41, No. 9, 1994

[3] Mang Cao, Kyung A. Kang, and Duane F. Bruley "Skin Cancer *Detection Based on NIR Image Analysis",* IEEE, pp. 431-436, 1997

[4] Pankaj Agrawal, S.K.Shriwastava and S.S.Limaye, *"MATLAB Implementation of Image Segmentation Algorithms"*, IEEE Pacific, pp.68–73.

[5] Asadollah Shahbahrami, Jun Tang "*A Colour Image Segmentation algorithm Based on Region Growing"*, IEEE Trans. on Consumer Electronics Euromicro, pp 362-368, 2010.

[6] T. Tanaka, R. Yamada, M. Tanaka, K. Shimizu, M. Tanaka, "*A Study on the Image Diagnosis of Melanoma"*, IEEE Trans. on Image Processing, pp. 1010-1024, June 2004.

[7] Fakhry M. Khellah, "*Texture Classification Using Dominant Neighborhood Structure*", IEEE Transactions on Image Processing, 2011, pp 3270-3279.

[8] Mariam, A.Sheha,Mai, S.Mabrouk, Amr Sharawy, "*Automatic Detection of Melanoma Skin Cancer using Texture Analysis"*, International Journal of Computer Applications, Volume 42, 2012.

[9] Guoqiang Peter Zhang, *"Neural Networks for Classification"*, IEEE Transactions On Systems, Man, And Cybernetics-Part C: Applications And Reviews, Vol. 30, 2000

[10] R.T.Bostock, E.Claridge, A.J.Hargetin, "*Towards a Neural Network Based System for Skin Cancer Diagnosis"*, IEEE, 1993.

[11] M. Emre Celebi, Hassan A. Kingravi, Bakhtiyar Uddin*,"A methodological approach to the classification of dermoscopy images"*, Computerized Medical Imaging and Graphics 31 pp 362–373, Science Direct, 2007

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He joined the EEE department of TKM College of Engineering as faculty member in 1990. He was with Saudi Aramco in 1996 to 1998 and worked in the field of power generation, transmission, distribution and instrumentation in the Oil and Gas sector of Saudi Arabia. He was with Water Supply department of Sultanate of Oman in 1985 to 1986 and worked with the maintenance of Submersible bore-well pumps and power supplies. He was with Saudi Electricity Company in 1979 to 1985 and worked in the Generation, Transmission and distribution fields. He worked with project management, Quality Management and he is a certified Value Engineer and Auditor for QMS. He is a consultant for Oztern_Microsoft, Technopark, Kerala and Consultant for Educational Projects of KISAT and MARK Research and Education Foundation.

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